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ABSTRACT

The paper deals with the problems of engineering education with special emphasis on mechanical engineering. The study is based on the situation at the end of the 20th century when the rapid development of information technologies stresses the need of a global context for all educational problems. The current social, economic and technical trends, especially the changes from the industrial society to the knowledge society, enlarge the goal orientations spectrum of research and higher education systems. These changes include the differentiation and/or diversification of higher education institutions, and the differentiation of bachelor, master, and doctor levels of universities and institutions of more practical orientations. At the same time in the research sphere, the actual quality assurance postulates and claims the differentiation of research centers denoted as centers of excellence or intellectual clusters and other levels of research and development activities. These trends presume a good standard of all forms of communications including fructification of modern technologies. Such a context includes the establishing of deeper international collaboration and co-ordination of all educational activities including evaluation, assessment, and accreditation of these activities and new emphasis on the quality, especially in the sphere of the highest levels of universities and other higher educational institutions. (Author/SAH)

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Problems of Engineering Education on the Threshold of 21st Century

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Problems of Engineering Education on the Threshold of 21st Century

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Abstract: *The paper deals with the problems of engineering education with special emphasis on the mechanical engineering. The study is based on the situation at the end of the 20th century when the rapid development of information technologies stresses the need of a global context for all educational problems. The current social, economic and technological trends, especially the changes from the industrial society to the knowledge society, enlarge the goal orientations spectrum of research and higher education systems. These changes include the differentiation and /or diversification of higher education institutions, the differentiation of bachelor, master and doctor levels of universities and institutions of more practical orientations. At the same time in the research sphere, the actual quality assurance postulates and claims the differentiation of research centres denoted as centres of excellence or intellectual clusters and other levels of research and development activities. The above-mentioned trends presume a good standard of all forms of communications including fructification of modern technologies. Such a context includes the necessiates the establishing of deeper international collaboration and co-ordination of all educational activities including evaluation, assessment and accreditation of these activities and a new emphasis on the quality, especially in the spheres of the highest levels of universities and other higher educational institutions.*

Keywords: *engineering, tertiary education, bachelor study, master study*

The need to explore the world in which we live is an inherent quality of man and the basic feature of human existence. Science and research are among the tools that man employs to satisfy his natural desire to acquire knowledge and that open up space for his better self-realisation. Education powers the mechanisms of social rise and decline thus keeping the whole society in motion. At the same time, it is a stimulator of life for democracy in the world that becomes increasingly complex, the crossing of borders to other cultures being an everyday matter. These are the reasons that drive us to constantly develop and enhance the system of education. The period immediately before entering next millennium seems to be the exact time to give these questions a serious thought.

Many of the ideas necessarily refer to university education as a whole but it is the engineering education that should merit the most attention since it is so closely connected with the most common human activity. All things that envelop us, that make our lives more pleasant but also more complicated have more or less passed through a production and more specifically a mechanical engineering process. Now that the material needs of people especially in the industrially advanced societies are satisfied, the conception of life in a "post-industrial" or "post-modern" stage of development is taking a more definite form with new processes denoted as "globalisation". Other new conceptions come into use such as "society of knowledge" or "education society". These denote educated and cultivated society with citizens who not only think highly of education, knowledge, and new discoveries in all fields of science but themselves strive for constant self-education to improve their own intellectual and cultural standard.

In the past, the tendency was towards an ever narrowing specialisation. The idea was promoted that progress in science can only be achieved with blinds so that a scientist can only see his narrow field of interest. In an exaggerated way, it could be said that such a scientist knows everything about nothing. This, in many cases, led almost to jeopardising life on the planet. In the course of the development of industrial societies, there was an abundance of knowledge and application results but this abundance also brought about extensive breakdowns, knowledge misuse, devastation of the planet, and other risks. The then top-level science was not prepared to face these shadows of industrialisation and educating institutions did not point them out. The situation was of course the more aggravated by deliberate secrecy due to the arm races and ideological controversy of a divided world. For these reasons, it is necessary that the conceptions of research and education projects should also consider the changing value structures, particularly the quality of knowledge, activities, and values. These should be not only values of environment, health, and society but also those of culture, aesthetics, and morals. Therefore, I believe that education in next millennium should be managed to provide a broader view and understanding of external social relationships as well as laws of nature for engineers. Of all the fields of human knowledge, the education of engineers will have to focus on the most important areas at least.

The end of this millennium has been marked by the transition from industrial to information society. Methods and means of computerisation, automated control, use of information technologies, and elements of artificial intelligence had already been employed in industrial society. In next millennium during the transition to information and education society, new perspectives will open to these methods and means. The users of these means will at the same time face higher demands and universities will have to prepare their students accordingly. Computer systems, e-mail communication, and the connection to the network of communication highways will be accessible to everyone. However, the main problem will be to provide users with good professional

education to be able to use these means in an intelligent way. Students will have to learn how to use information systems purposefully and efficiently and how to distinguish between substantial and redundant information.

The problems of development and protection of living environment will have to be given extraordinary attention in educating engineers at universities. The engineering graduates will have to be equipped with comprehensive knowledge in technology, science, and they will have to acquire practical skills for the protection of environment. Each designer should, even at the initial stage of the design of technical equipment, try to achieve the most friendly impact on the environment of the devices when they operate as well as when they become morally and technically outdated. Additional remedies of unsuitable and harmful measures are very expensive and are mostly introduced only after the environment has been impaired. Education towards the protection of environment should be part of basic courses. Specialised courses should only provide general, fundamental knowledge, including an introduction to the environment problem area, theory of environment, creation of environment, and protection of environment.

The economy in most countries, and after 1990 also in the Czech Republic, is based on market economy principles. The engineering education has also to adapt to this situation mostly in two aspects - regarding the economy and the quality.

Students of technical universities must have sufficient knowledge of the basic principles of economics and productivity. When designing a new product the engineer must always consider the basic requirements for the final product to be competitive, i.e. its price, look, functionality, and quality. Courses of modern economics and marketing should form an integral part of engineering education. This approach, like in the case of ecology, will have to be applied not only to specialised economics courses but also to most technical courses of application character. This category includes also the necessity of attaining the shortest possible duration of the conception-design-production-marketing process. It is in this area that less advanced countries can compete with the more advanced ones. This again presumes a well functioning information system enabling to design individual product components almost simultaneously. This means even before the design of a component takes the final form of technical drawings. Such a design procedure is called a "competitive design" and may considerably speed up the construction design phase and thus the overall product implementation time. If, in connection with production, we speak about quality, we mean the quality of the design work and of the product. Students of the Master courses should get a general idea of these problems in specialised courses and in courses focused on selected problems, they should acquire knowledge that is more detailed.

An important issue in engineering study is the introduction of value-oriented education of students. In the Czech republic, since the beginning of technical universities, the education has been aimed at transfer of knowledge and information and improvement of common routine work with less accent being put on the creation of a student's technical personality and creative thinking. The present system, when funding is allotted to universities according to the number of courses and the number of university teachers of all categories is determined according to the hours of lectures and seminars required, leads more to a run for the greatest number of study hours rather than to the achievement of the best quality of courses and to orientation at students' individual study. Education towards independent thinking connected with an appropriate amount of inspiring specialised information and practice may enhance the engineering teaching of the students. Students educated in this way will find much better practical placements and will be able adapt to a rapidly changing technical development and the needs of the economy. Moreover, a student with such a type of education will be able to get oriented in the profusion of information of all kinds and find the right direction and attitude in a globalized world.

When stressing the necessity of value-oriented education of students' personalities, also the necessity must not be overlooked of the creation of his comprehensive view of society and providing him with the possibility to study courses in humanities and basic philosophical conceptions. The knowledge of at least two foreign languages should be a pre-condition for full integration in the international information network, for presenting papers at international conferences, and for the need to defend the scientific conclusions and technical designs.

If we have mentioned the rapidly developing technologies of all kinds, we must also stress a new approach to the education of students. Pre-set, rigid curricula still prevail in university education as one of the results of the past. The development of technologies and less clear-cut boundaries between disciplines will necessitate the introduction of shorter and interconnected education areas. In other words, our education and study areas will have to be transformed into modules which link up to each other and can be re-arranged according to changing requirements of application sciences, economy and labour market. In this way, those students who want to embark a particular technical career or who are talented and want to do research work will be able to select for the required area of knowledge.

The present social and economic trends, as it is the case in other advanced West European countries, will make it essential that a much greater part of population of active or productive age should be equipped with knowledge sufficient develop useful skills but also to accept and integrate the existing innovation processes and discern important innovations of knowledge and technology. This means that a much greater part of population than up to now has to have university education. This of course brings new problems. One of the most apparent ones is the fact that the existing education structures based on old traditions do not come up to these standards.

Another problem is that not all of this larger number of students are capable of coping with the existing university curricula. If we take only intelligence as a basis, i.e. the IQ factor in individual fields of education, we get, according to the present distribution, the values as shown in Tab. 1. This situation is plotted in Fig. 1 with an additional category of non-university students.

Tab. 1 IQ characteristic of selected social groups of population

Social group	IQ mean value	Standard deviation	percentage
Whole population Normal distribution	100	15	100
Secondary school graduates	110	12	40 - 50
University graduates	118	12	10 - 15

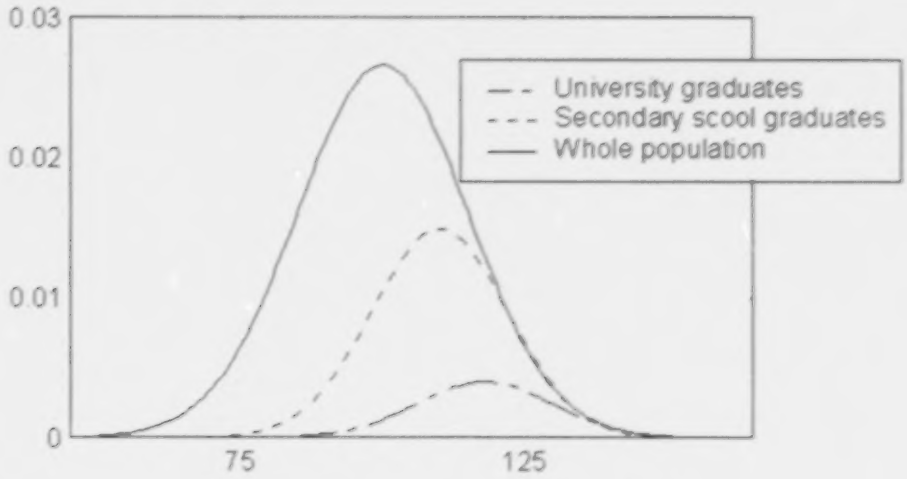

Fig. 1 Distribution densities of IQ for individual social groups

The IQ criterion alone is of course not complete. Motivation and hard work can make up for part of intelligence. However, a successful university student can hardly be imagined with an IQ of 85. On the other hand, even a student with a high IQ needs some motivation and his study must be supported by diligence. It is also known that some types of skill and talent will show much later after a certain level of maturity is reached. At any rate, the table and plots do show the way of increasing the number of students in tertiary education, which is to increase the university-education throughput rate. This will lead to a diversification of universities and to a necessity to have, apart from the university-type schools, also non-university educating institutions for students who could be characterised as follows:

- relatively lower IQ (from 95 to 115)
- very good structure of personality
- good motivation to study as a result of education being more important in the labour market

These facts must necessarily affect the system of university education, necessitating

- changes in the contents, form and methods of university teaching,
- changes in the way a university graduate is viewed in the labour market place and the redefining of typical activities performed by university graduates (Bachelors, graduates from university and from non-university educational institutions).

At the same time, however, the elite study programmes will have to be maintained and developed since these graduates' position in the labour market will be much better than that of other university graduates. It is clear that this will mean a selection by the students' motivation and structure of personality but also by intelligence and creative abilities.

This will be a new type of diversification, which will affect the targeting of university education. The idea that the major goal of university education is to prepare young people for scientific and research careers is now becoming obsolete. The targets of different types and grades of universities may be quite different. This targeting may include not only professionally structured units but also problem-oriented or pragmatically conceived orientations. This development has been observed in the past decades in advanced countries, and also at universities educating at different levels and with different targeting. These differences in the target level of universities must become transparent. We owe this to students who need to know where to put their time and efforts before they start to study. This also means that the idea of an alleged equality of all universities should not be adhered to at any cost. We will have to be more realistic in this point. It becomes increasingly frequent that university graduates get jobs not because they have a certificate of some kind but because they show their professional skills and creative abilities.

The new law on higher education in the Czech Republic grants possibilities to solve many of the problems and to follow new

trends. All ideas mentioned, logic and feasible as they may seem, will still be resisted by some academics and administrators because of their conservative way of thinking. If we want our economy to get out of the present recession, we must provide it with able people.

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